Combining Passive Microwave Sounders with CYGNSS information:

Observations during Hurricane Harvey

M. Schreier

Jet Propulsion Laboratory, California Institute of Technology, USA

Contributors:

Shannon Brown, Jeffrey Steward, Evan Fishbein, Bjorn Lambrigtsen, Derek Posselt, ...

Jet Propulsion Laboratory
California Institute of Technology

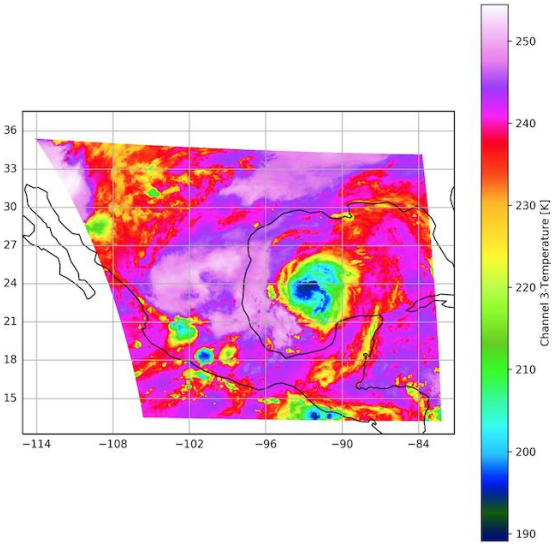
EPOCH and Hurricane Harvey

- "East Pacific Origin and Characteristics of Hurricanes"
- Was – luckily - not really restricted to Pacific
- PI: Amber Emory
- Goal: Using observations from instruments of on Global Hawk to observe hurricane intensification

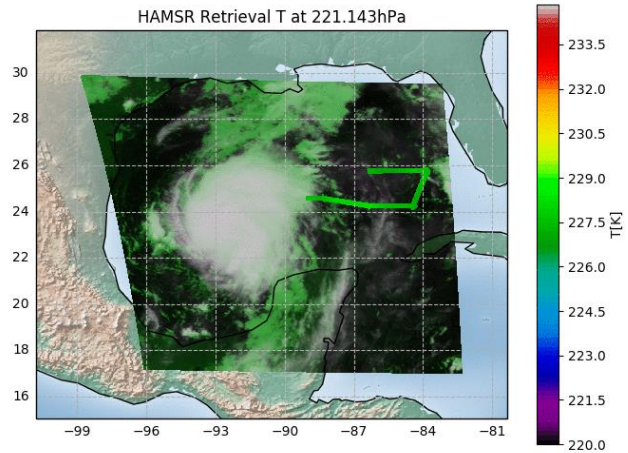
- Instruments on the Global Hawk:
  - EXRAD (radar)
  - AVAPS (dropsondes)
  - HAMSR (microwave sounding)

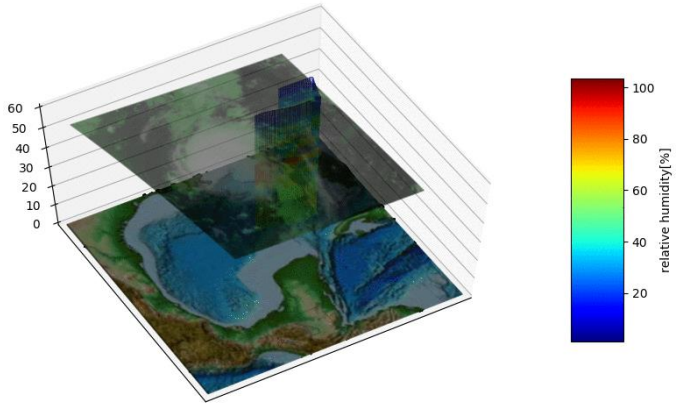
- Duration: August 2017

- 2nd Science flight was on August 23rd/24th, 2017 – during Harvey's intensification over the Gulf of Mexico



The Flight Path over Harvey - as seen by HAMSR





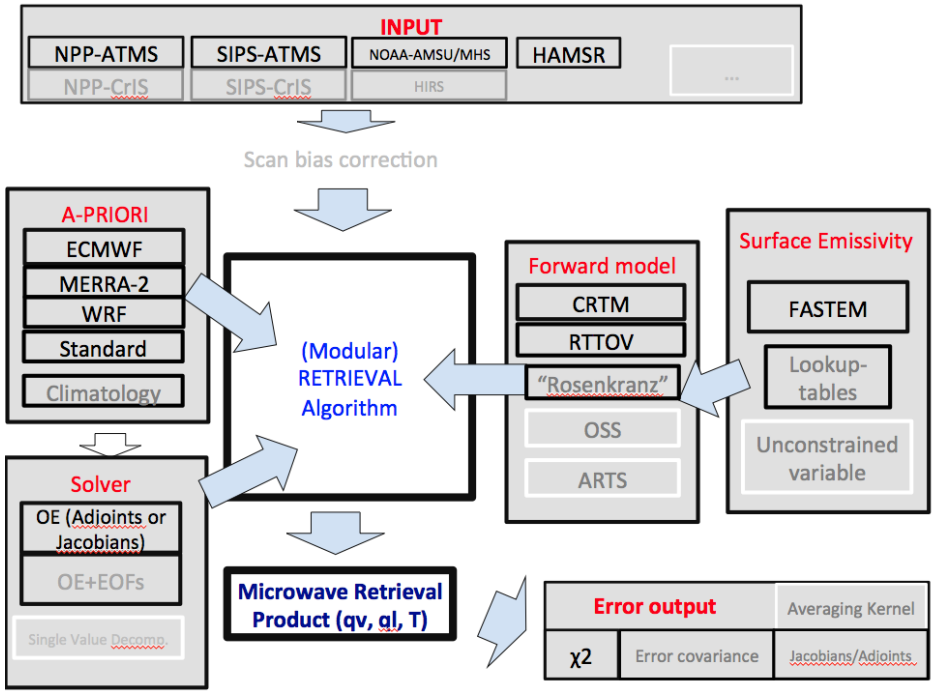
Animations of the flight path:

- [Arrival and Departure no shown]
- Upper animation shows the retrieved temperature at a level of ~200 hPa
- Warm core is visible:
  => Change from blue to green (2-5 K), when flying over the core
- Lower animation shows retrieved relative humidity at nadir
- Retrievals are done with retrieval system called “RATATOUILLE”

Short Introduction:
The Retrieval System RATATOUILLE - The Idea

Retrieval **A**lgorithm **T**estbed

with **A** variety of **T**ransmutable **O**ptions
to **U**nderstand **I**mpacts of
Limiting components and **L**imitations
from too high **E**xpectations



Or:

Trying to create a retrieval system that allows "exchanging of components easily"

- No tweaking
- No tuning
- No preference

System is mainly based on available components

RATATOUILLE – Current State

Type	
Language	Fortran 2003 (some bash/python)
Instruments	ATMS (h5), ATMS-SIPS (nc), AMSU-A/B, MHS (binary) HAMSR (nc)
RTA	CRTM RTTOVS
Background	"Standard" ECMWF MERRA-2 WRF
"Addable" information	CYGNSS-wind (adapted)
Covariance Matrices	Various, based on PCA
Solver Approach	OE, Adjoints/Jacobians from RTA (LMBM-Minimiz.: N. Karmitsa)
Error analysis	X^2

Premise:

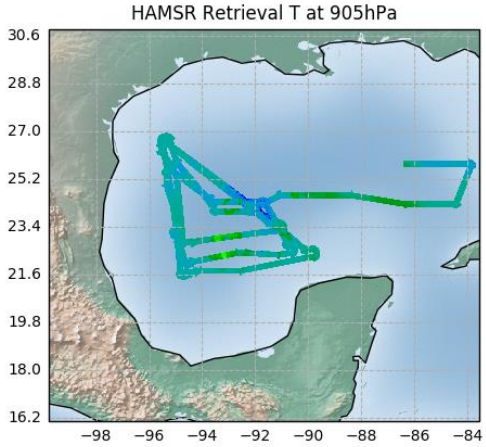
Keep it Modular and interchangeable

Reason:
Allow a comparison of specific components
without affecting all other components

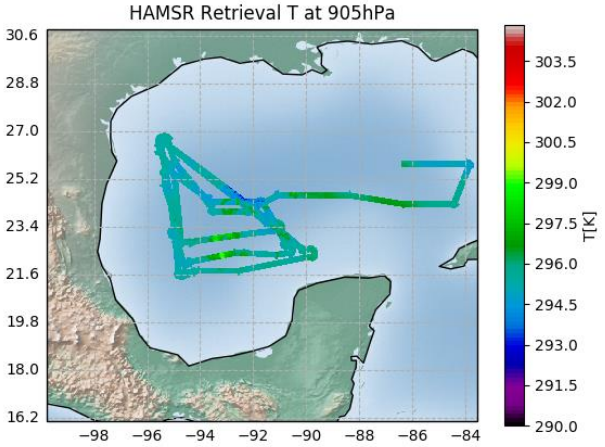
HAMSR Retrieval during Harvey Flight: Near Surface Temperature

Retrieved Temperature near the surface (900hPa) with different kinds of wind information

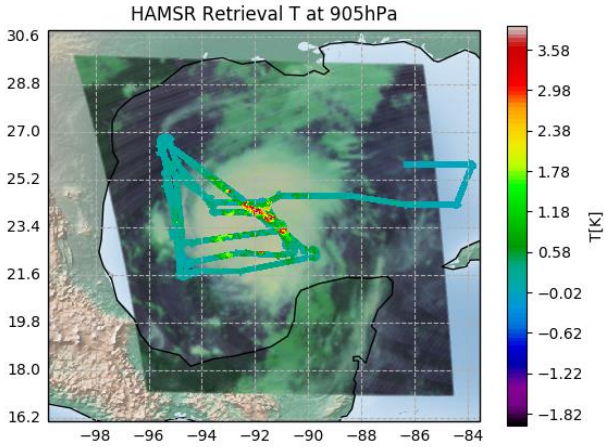
ECMWF-wind



CYGNSS-wind



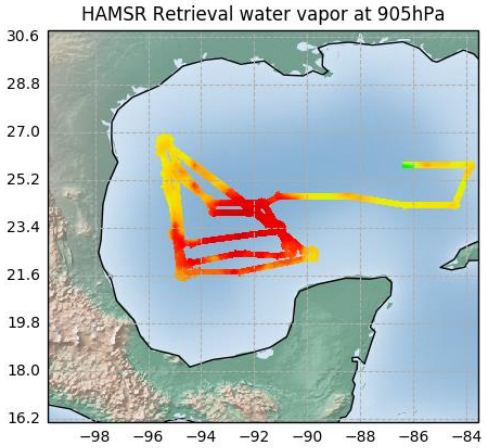
Difference



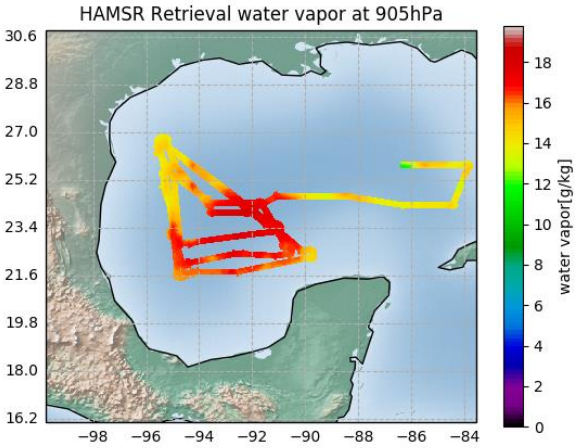
HAMSR Retrieval during Harvey Flight: Near Surface Water Vapor

Retrieved water vapor near the surface (900hPa) with different kinds of wind information

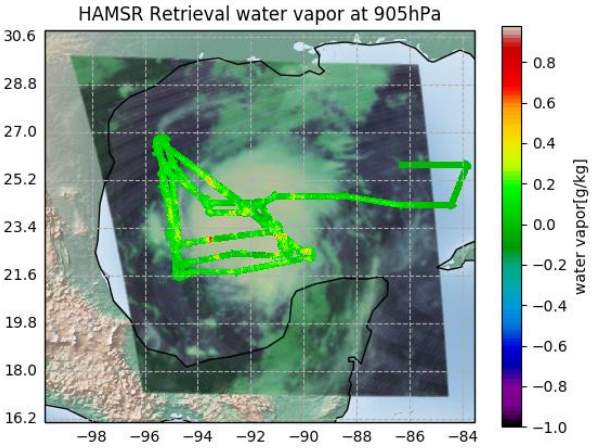
ECMWF-wind



CYGNSS-wind

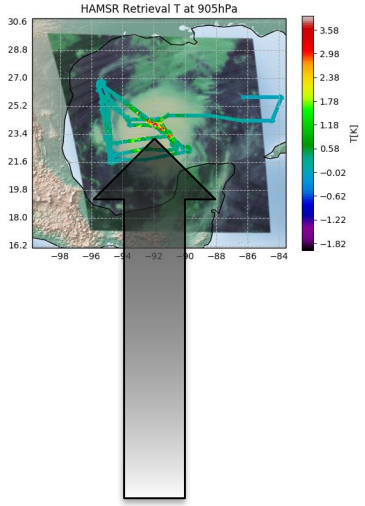


Difference



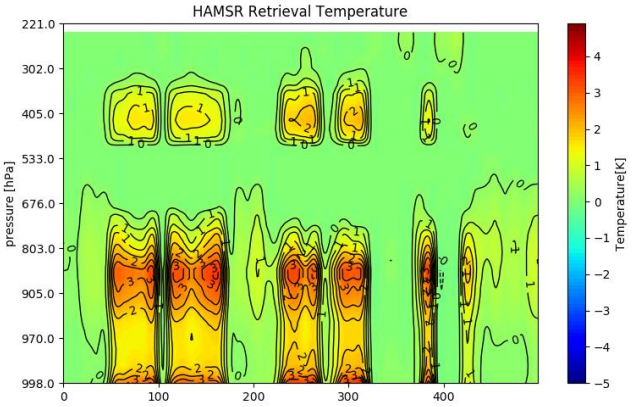
Flight over core:

Vertical Difference in retrieval with ECMWF or CYGNSS information

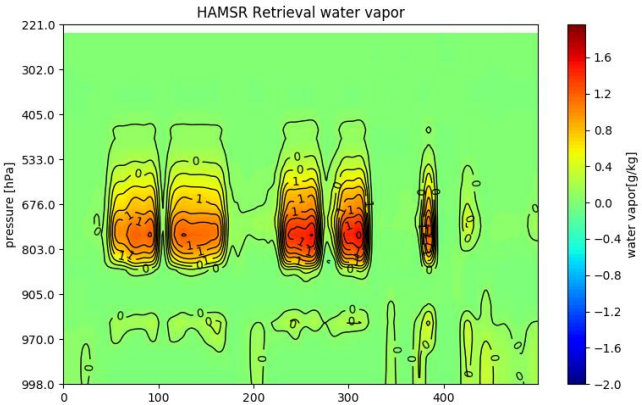


Plots show difference between retrieval with ECMWF-wind and CYGNSS wind during highest differences

Temperature



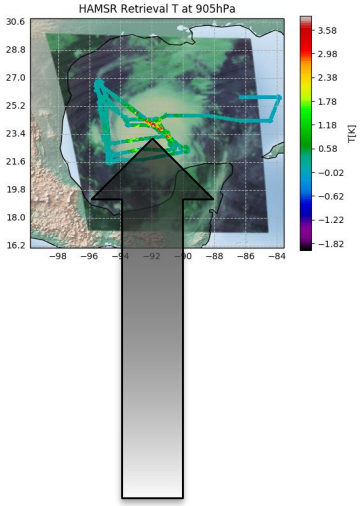
Water vapor



- Error is “propagating vertically”
- Temperature difference up to 4 K
- Water vapor differences can reach 1 g/kg

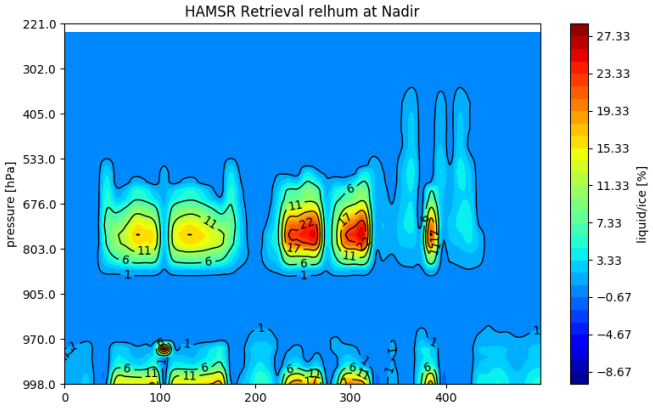
Flight over core:

Vertical Difference in retrieval with ECMWF or CYGNSS information

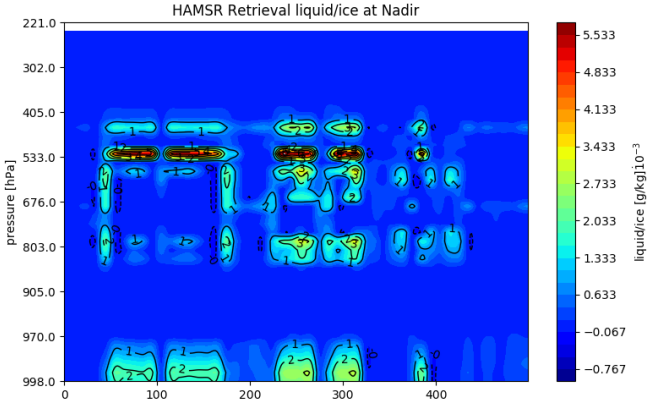


Plots show difference between retrieval with ECMWF-wind and CYGNSS wind during highest differences

Relative humidity



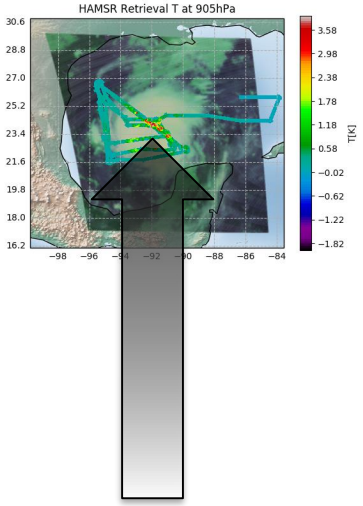
Liquid/ice



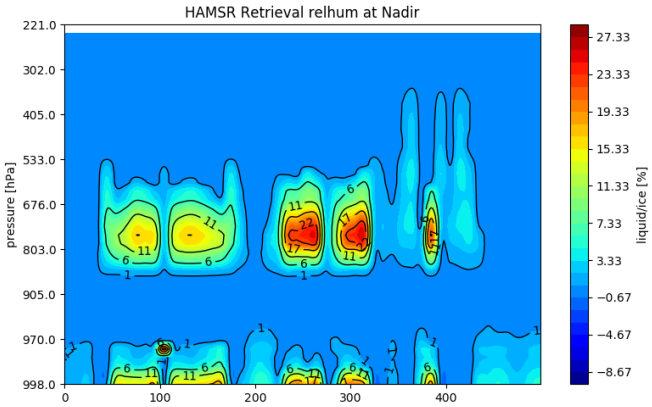
- The impact on the resulting relative humidity is up to 25 %
- Changes in liquid water content are around 5×10^{-3} g/kg

Flight over core:

Vertical Difference in retrieval with ECMWF or CYGNSS information

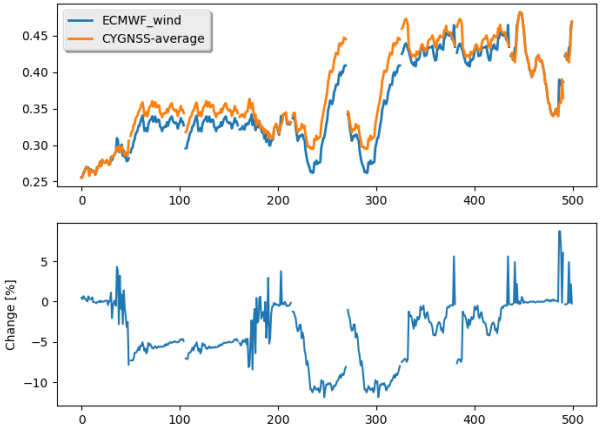


Relative humidity



χ^2- Error

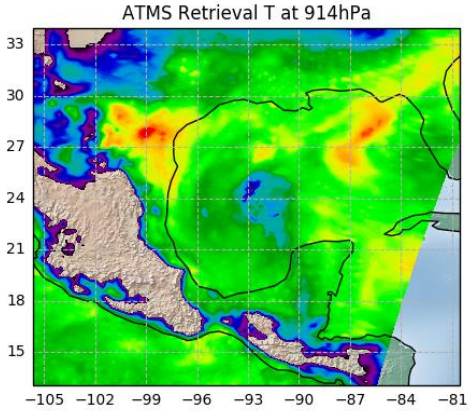
Plots show difference between retrieval with ECMWF-wind and CYGNSS wind during highest differences

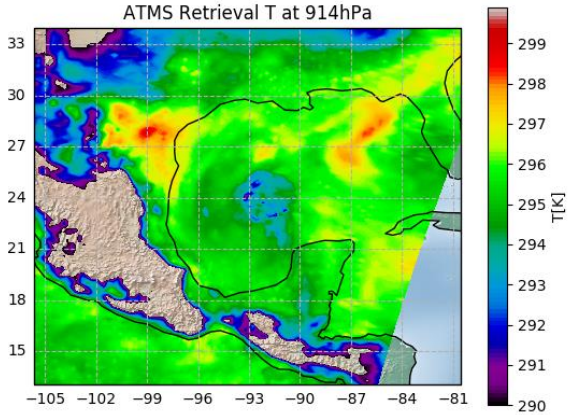


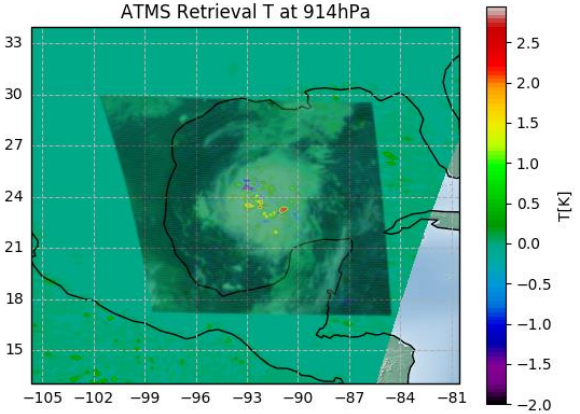
- Impact on Xi is not very significant
- Error sources like scattering are still dominating
- However, overall the impact can be up to 10%.
- Note: that we can also see spikes of 5 % increase in error

Is this transferrable to Satellite retrievals ?

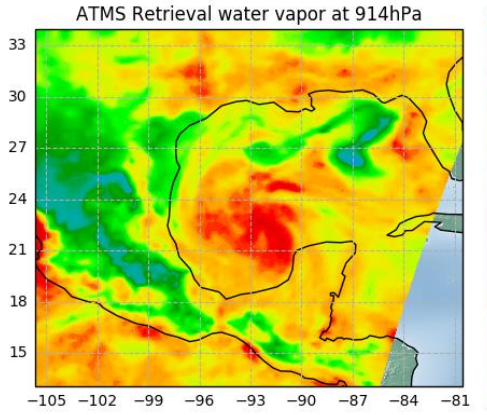
ATMS Retrieval during Harvey Flight: Near Surface Temperature

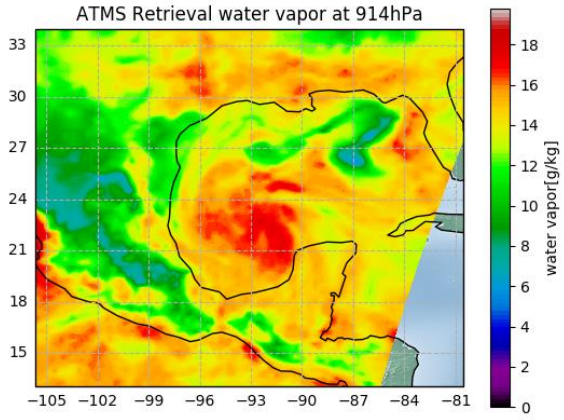


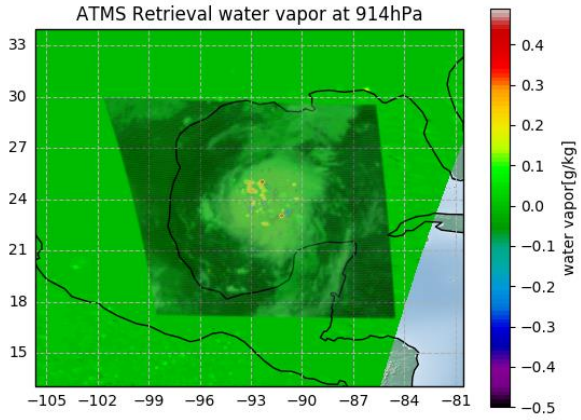




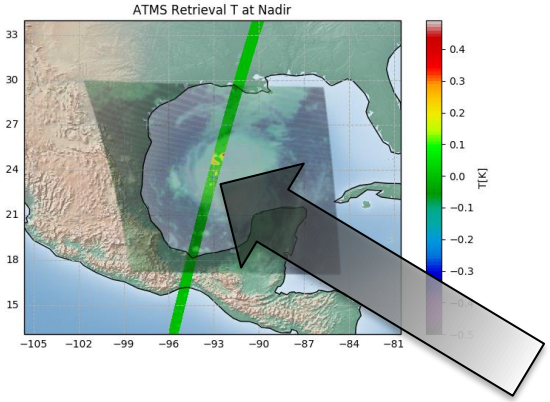
ATMS Retrieval during Harvey Flight: Near Surface Water Vapor



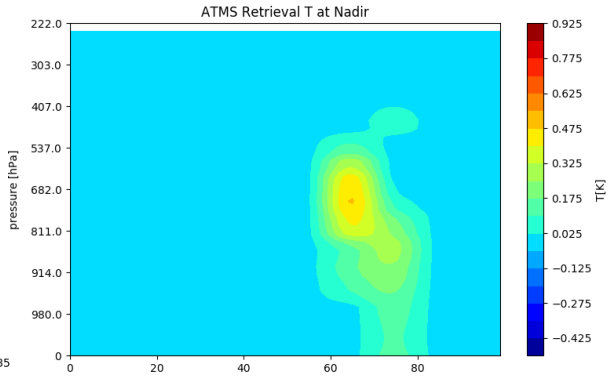




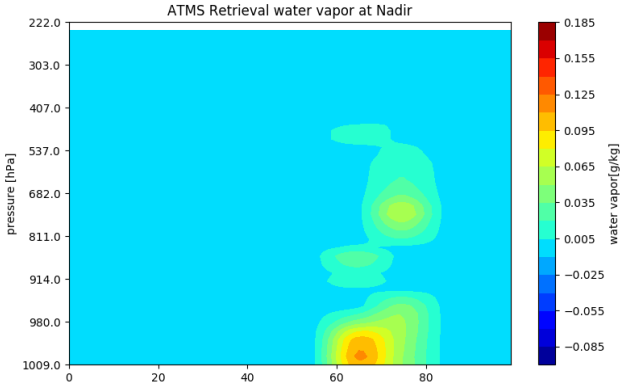
ATMS Retrieval during Harvey Flight: Vertical - with or without CYGNSS information



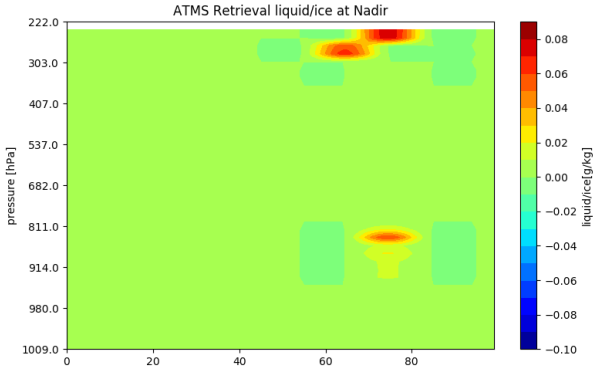
Temperature



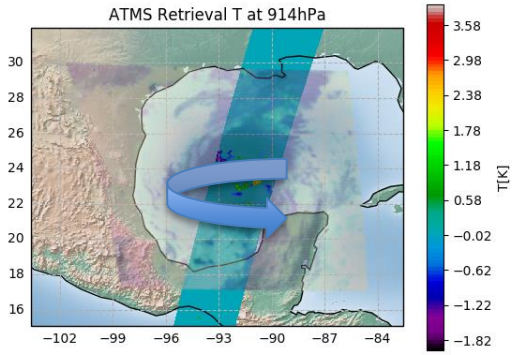
Water vapor



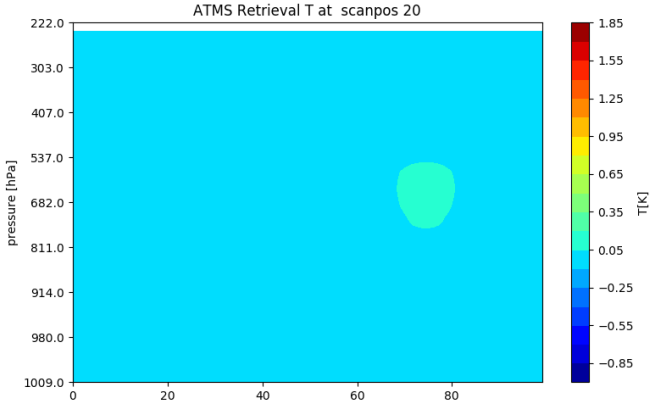
Total liquid



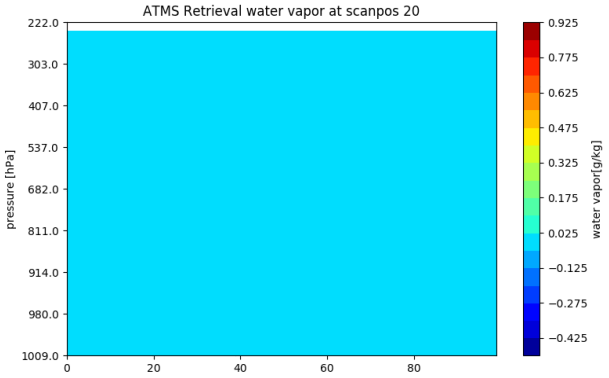
ATMS Retrieval during Harvey Flight: Vertical - with or without CYGNSS- LOOP



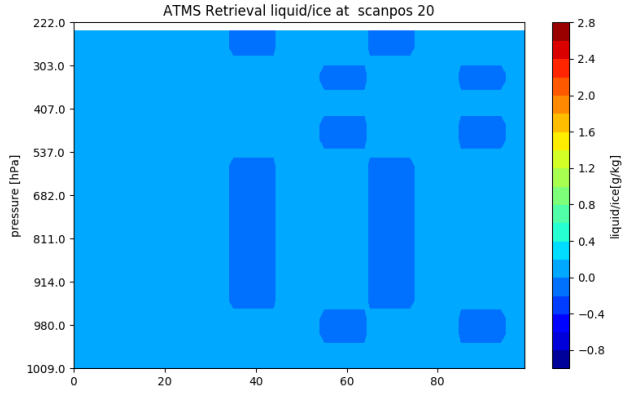
Temperature



Water vapor



Total liquid



Conclusion

- Tested the implementation of CYGNSS data in microwave retrieval

- Comparison of HAMSR retrievals with CYGNSS-wind and ECMWF-wind shows differences
- Difference occurs mainly around the center of the storm
  - up to 4 K in temperature
  - Up to 1 g/kg water vapor
  - [Up to 10^{-3}g/kg liquid/ice content]

- The difference is “spreading upwards” in the vertical profile

- Error in obs – calc can decrease by 10%

- Scattering is still the dominant error source

- Comparison of ATMS retrievals with CYGNSS-wind and ECMWF-wind shows smaller differences
- However: smaller impacts – might be because of bigger footprints